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December 7, 1960

HAN-77209

FUELS PREPARATION DEPARTMENT

MONTHLY REPORT

NOVEMBER

1960

HANFORD ATOMIC PRODUCTS
OPERATION

GENERAL ELECTRIC

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FUELS PREPARATION DEPARTMENT
MONTHLY SUMMARY REPORT
NOVEMBER - 1960

PRODUCTION

Finished production for November was 535.7 tons, or 99% of forecast.

At month end the bare uranium inventory was 1,440 tons compared to 1,337 tons for October. Finished inventory was 953 tons at month end compared to 970 tons for the previous month.

ENGINEERING

Present Reactor Fuel Elements

Ten fuel element failures occurred in November. This is slightly more than average monthly experience thus far in 1960.

Eighty-one columns of self-supported fuel elements have now been irradiated to a goal exposure of 1,200 MWD/T. No hot spots have been observed.

Irradiation performance of dingot uranium has not been found to be significantly different from ingot uranium; dingot cores will no longer be segregated in recovery and reprocess lots.

The prototypic ultrasonic welder for attaching projections to fuels was satisfactorily used to produce approximately 50 tons of natural I&E, three rail, bumper fuel elements. Laboratory work on the prototypic ultrasonic weld tester was completed. This instrument detects abnormalities in the electrical flow to the transducer when bad welds are made. Work is under way to apply this test in the routine operation of the ultrasonic welder.

Design and fabrication of equipment to produce the initial test run of oversize I&E fuel elements for the overbore program is essentially complete.

Two tests were found necessary to completely inspect the closure zone of present production reactor fuel elements. One employs ultrasonic shear waves and the other longitudinal waves. Circuitry was developed to enable the prototype tester to perform both these tests simultaneously.

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NPR Fuel Elements

The initial irradiation of fuel elements produced by the full process as defined for N-Reactor fuel production was begun this month; four single tube elements enriched to 1.6 weight per cent U-235 were charged in each of loops KER-2 and KER-4. These irradiations are calculated to simulate the in-reactor conditions and performance of the outer tube of the composite tube-within-a-tube N-Reactor element. It is planned to terminate the KER-2 irradiation in January at an exposure of about 1,000 MWD/T, to secure preliminary data and carry the KER-4 charge to nominally 3,500 MWD/T.

Two vendor contracts for zirconium shells were approved; initial deliveries are scheduled in January. Agreement was reached on the third contract and approval is expected shortly.

Seven Zircaloy, two uranium, and sixteen composite extrusions were carried out to: Evaluate billet assembly and extrusion variables; provide material for heat treating studies at NMI; evaluate the "cupping" process for the production of shells from Zircaloy billets, and to provide material for KER loop charging.

Evaluation of candidate fuel element supports was completed. It was determined that the preferred arrangement is one comprising thin iron shoes mechanically attached by crimping to Zircaloy supports welded to the fuel cladding. The iron shoes, being soft, lead to minimum abrasion of the protective oxide layer on the Zircaloy process tube during charging and subsequent differential thermal expansion.

Eighty-seven pieces were end-closure brazed. An investigation is under way to determine the cause of porosity under the caps observed in a number of pieces. Nondestructive testing of braze closures was started in the Pilot Plant this month.

Studies on NPR fuel element-warp indicated that warp occurs on heating and not on quenching as formerly believed; the cause of the warp is deduced to be preferred orientation.

GENERAL

Manufacturing yield for 8" I&E was 86.1 per cent compared to 88.3 per cent for the previous month.

Two autoclave failures occurred during November, bringing the total for the year to nineteen.

GENERAL (Cont'd)

A new record high operating efficiency of 95.7 per cent was attained in November. The previous high of 95.6 per cent was attained in February, 1959.

Project work on the new fuels facility is on schedule. The bid package for chemical equipment installation was forwarded to HOO-AEC during the month.

PERSONNEL STATISTICS

Number of employees: October 31, 1960 806
 Number of employees: November 30, 1960 822

	<u>Exempt</u>	<u>Nonexempt</u>	<u>Total</u>
General	1	1	2
Manufacturing	76	339	415
Engineering	37	28	65
Financial	12	6	18
Plant Facilities	36	277	313
Relations Practices	5	4	9
TOTAL	167	655	822

STAFF

General Manager, Fuels Preparation Department
 Manager, Manufacturing Operation
 Manager, Engineering Operation
 Manager, Financial Operation
 Manager, Plant Facilities Operation
 Manager, Relations Practices Operation
 Special Studies Assignment

R. L. Dickeman
 W. M. Mathis
 L. H. McEwen
 W. S. Roe
 E. Hilgeman
 R. W. McCullugh
 J. W. Talbott

PATENT SUMMARY - NOVEMBER, 1960

All persons engaged in work that might reasonably be expected to result in inventions or discoveries advise that, to the best of their knowledge and belief, no inventions or discoveries were made in the course of their work during November, 1960, except as listed below. Such

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persons further advise that for the period therein covered by this report, notebook records, if any, in the course of their work have been examined for possible inventions or discoveries.

- G. R. Hanson - A Self-Aligning Welding Chuck for Cylindrical Fuel Elements, 11/28/60.
- I. V. Nelson - Inert Gas Welding Torch with no Seals on Water and Gas.
- D. C. Worlton - A Method of Insuring the Integrity of Welds Made by Ultrasonic Welding Techniques, 11/15/60.

RL Dickman
General Manager
Fuels Preparation Department

RL Dickman:mkm

MANUFACTURING OPERATION

November, 1960

CURRENT OPERATIONSProduction and ProductivityStatistics

	8"	NORMAL						6" C 6" O		ENRICHED			Total
		Solid	8" I & E				Water	Water	6" I & E				
			CIIN	CIVN	KIIN	OIIN			OIIIN	Mix	Mix	CIIE	
Current Month's Production						(B)							
Acceptable Fuel Elements Produced (Tons)	-	41.0	2.4	184.1	217.1	35.4	-	-	17.6	38.1	-	535.7	
As % of Forecast Production	-	71	-	87	145	58	-	-	98	141	-	99	
Cum. % of Forecast for Current Qtr.	74	85	-	117	124	58	-	101	97	119	-	102	
As % of Past 3 Month's Average Production	-	80	-	86	84	-	-	-	98	83	-	81	
As % of Past 12 Months Average Production	-	89	120	89	91	-	-	-	147	103	-	84	
% of Forecast Achieved Last Fiscal Quarter	82	157	12	100	112	-	93	91	97	97	66	99	
% of Forecast Achieved Last 4 Fiscal Qtrs.	107	115	38	103	105	-	102	103	94	103	85	103	

Operating Efficiency

Current Month (%)	95.7
Forecast (%)	93.0
Previous Month (%)	92.3

Manufacturing Yield

Current Month (%)	-	89	-	87	85	-	-	-	86	88	-	
Forecast (%)	87	87	-	87	87	78	-	-	87	87	-	
Previous Month (%)	90	89	-	89	88	-	-	86	78	86	72	
Bare Uranium Available for Processing (Tons)	-	76	45	527	347	133	14	4	32	72	190	1440
Finished Products in Storage (Tons)	61	100	8	201	394	35	6	18	34	51	45	953
Special Products Finished (Pieces)												0
Uranium Utilization												94.9

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ACTIVITIES

Production

Finished production for November was 535.7 tons, or 99 per cent of forecast. The below forecast production resulted from processing and inspection problems experienced in fabricating the first production run of OIIIN bumper fuel elements. Most of the bumper pieces were produced as scheduled but part of them did not reach finished storage by month end. Movement of these pieces between the 313 AlSi Shop and 306 Pilot Plant for various processing steps has required double handling and rescheduling of work which has resulted in poor yields and delays in getting the material to finished storage. Temporary improvements in the process flow are being made as work progresses, however, projection fuel elements will require special "out-of-line" processing steps until completion of Phase I, Project CGF 903 in July, 1961. A total of 35 tons of OIIIN bumper fuel elements reached finished storage during November. 55 tons were welded, 52 tons of which was acceptable after welding (93.8 welding yield).

Yields also affected this month's production adversely. Approximately 52 tons of OIIN dingot cores, with a higher than normal amount of surface hydrogen were processed early in November. Reject categories associated with high porosity levels were experienced on this material which is attributed to increased humidity during August and September when the material was produced at the vendor's plant.

Production from ten canning lines of OIIIN elements was diverted after facing to the 306 Pilot Plant. This was done to pre-test the new process flow and end closure DC welding techniques established for use in the 313 bumper conversion project.

Sixteen canning line shifts were utilized to produce OIIE fuel elements which will have bumper attachments welded starting early in December. Canning of this material was necessary to assure that the two-shift welding operations scheduled for next month will not be delayed for lack of required materials. Most of the enriched bumper fuel elements to be produced will be for the E-N demonstration loading in H reactor tentatively scheduled for April, 1961.

Fuel element canning operations continued at ten canning line shifts per day on a two-shift basis. A total of 200 canning line shifts were operated during the month.

The sub-standard solid cores remaining from the October production run were gathered, boxed, and transferred to scrap during November. Approximately 4400 cores were scrapped, completing the phasing-out of the 8-inch solid fuel elements.

Fabrication of the 4-inch I & E "boll" pieces for the E-N load has been delayed because of the lack of a process. Eccentricity of the hole in relation to the O.D. of the as-received tubing, inclusions of some very hard material, and scoring in the internal hole are factors which are delaying the development of tooling for the operation. It is expected that a satisfactory process will be in place by early December.

Yield Control

The manufacturing yield for 8-inch I & E fuel elements of 86.1 per cent for November reflects a significant decrease from the comparable yield of 88.3 per cent for the previous month. The large amount of dingot material processed in November adversely affected the yield by increasing the braze layer integrity rejection rate. An increase in the marred surface category rejections is associated with the installation of the second automatic stamper and auxiliary conveyor system.

The November manufacturing yield for 6-inch I & E fuel elements was 87.0 per cent as compared to the corresponding yield figure of 83.5 per cent for October.

Two autoclave failures occurred during November, bringing the total for the year to nineteen. Water entry to the core was through gross defects in the male weld.

Construction Projects

CAF-847 - New Fuel Cladding Facility

Nearly all of the underground work within the building has been completed. Floor trenches are being poured. Erection of structural steel on the mezzanine has begun. Siding is being erected on the heating and ventilating facility.

A favorable quotation was received on wet blasting equipment. It is planned, however, to issue a new package for dry blast equipment in view of operating cost advantages and reduced air requirements with the latter.

The truck on which the leak detectors were being shipped was broken into in Dayton, Ohio, and parts were stolen from the leak detectors. When the units are received, at least one will have to be sent to California for rebuilding.

A universal grinder was obtained from excess at a saving of \$15,000 to \$20,000.

The bid package for chemical equipment installation was sent to the AEC for processing on November 16.

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CAF-894 - Increased Compressed Air Capacity, 300 Area

Bids were opened on November 15. The low bid was \$72,400 on the combination of compressor facility and 3717 addition. This is well within the available funds but well over the fair cost estimate of \$60,000.

CGF-903 - Projection Fuel Element Modifications, 313 Bldg., Phase I

Requisitions have been issued for the welder power supplies.

CAF-915 - Increased Warehouse Space, 303 Area

The work authority for this project is being prepared by the AEC.

Other Activities

The following pieces were processed through the Fuel Recovery facilities during November:

8" Solid	1,844
8" I & E	26,357
6" Water Mix	1,440
	<hr/>
Total	29,641

PLANT CONDITIONS, INCIDENTS, AND IMPROVEMENTS

General

An operating efficiency of 95.7 per cent for November represents a new record high which exceeds the previous high of 95.6 per cent which was attained in February, 1959. Of the total outage time 49 per cent was due to equipment outages and 51 per cent was for operational reasons. The major contributors to the equipment outages were the canning jacks and agitators.

A total bare inventory of 1,440 tons was on hand at month end, a 2.1 month supply. This is approximately the same level as reported last month, and the scheduling of storage space continues to be critical.

Finished product inventories at the end of November totalled 953 tons. Based on current reactor requirements as shown on the most recent forecast, the finished inventory represents a 1.4 month supply. Increased reactor charging which is scheduled for December is expected to reduce the finished inventory.

One shipment of scrap was made during the month totalling 60,247 pounds of normal uranium and 4,823 pounds of enriched uranium contained in scrap, C-6, and filter press canvas.

During the month the laboratory examined several cores which showed surface cracking. The first sample examined was a KR recovered core. The surface cracks on this piece were readily observable since the sodium hydroxide in the fuel recovery process had preferentially attacked the metal at the boundaries of the cracks. Transverse sectioning and polishing of this core revealed that the cracks penetrated to a depth of 0.4 cm. Polarized light observations showed transgranular cracking rather than just a cracking of the grain boundaries. A chemical analysis determined that the iron concentration in this core was 606 parts per million.

Following this investigation, other cores were found showing this cracked condition. These other cores were found in the normal production stream at pickle inspection, some from one ingot in a KZ lot and some from two ingots of enriched uranium KS lots. A peculiar aspect of the enriched cores is that some pieces from the same ingot exhibited cracking while others did not. Chemical analysis for iron showed in each case that those pieces evidencing cracking had high values while those pieces from the same ingot not showing cracking had normal iron values. Iron analysis on the cores examined are as follows:

	<u>Recovered</u>	<u>Virgin</u>	<u>Ingot S 35465</u>		<u>Ingot S 35466</u>	
			<u>Cracked</u>	<u>Uncracked</u>	<u>Cracked</u>	<u>Uncracked</u>
ppm Fe	606	628	533	89	582	68

Studies have been underway regarding improvement of weld inspection. Numerous tests have indicated that a better weld inspection (particularly for pin holes) can be attained by etching fuel elements prior to inspection. The etch process aids the inspection process in several ways. It produces a dull, "satiny" finish on the weld (which is easier to inspect); it removes contamination in the weld which may mask a hole type defect; and it appears to selectively attack discontinuities in the weld such as cracks and pinholes, which tends to highlight these defects. Weld inspection station is, therefore, being relocated accordingly and should be completed about February 1, 1961. This will aid in upgrading closure integrity.

To assure probe protection for the bond and penetration testers, a semi-automatic mandreling unit has been designed and prototyped. Present indications are that it will operate satisfactorily.

Present Quality Control Standards require LiAl cores to be canned within a five minute time limit after machining. This limit is imposed to avoid possible hydrogen contamination of the lithium material.

A feasibility study for relaxing this rigid time limit was recently completed. The results of this study showed no significant difference in hydrogen content in cores exposed 2-1/2 hours and cores canned with the specific five minute time period. Extending the exposure time to two hours permits us to utilize both manpower and machinery more

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effectively. Specifically, relaxing this time specification will result in the elimination of a metal handling step, increase the efficiency of the required inspector, and increase production by reducing idle machining time.

Three fuel elements (6" bare) have been removed from furnace channels this month. This is the first time a core has been lost in the channels for about a year.

A procedure for removing the cores has been developed and appears to work quite satisfactorily. A tapered rod slightly larger than the core inside diameter is inserted into the core and then tapped with a hammer. The core can then be removed by withdrawing the rod. The furnace power must be turned off for the inserting of the rod in the core since the magnetic field will force the rod to the side of the channel and make it very difficult to place the rod in the hole.

On November 4, 1960, a 3900 lb. autoclave assembly fell back into an autoclave as it was being removed by a two ton hoist. This assembly fell approximately six feet into the bottom of the autoclave when the hoist load line pulled through the cable clamps, which attached it to the hoist.

The special investigation resulted in several recommendations to reduce the possibility of a similar accident. Maintenance Engineering is currently studying the possibility of slowing the hoist speed and installing a load limit switch. Also, redesign of the base and pin assembly to assure positive pin location will be investigated.

On November 15, 1960, the main vertical shaft on a canning basket broke and fell into the furnace. The canning jack vibrator also fell into the furnace and air from the vibrator blew molten AlSi over the area surrounding the furnace. This accident occurred during early morning start-up so no one was in the area to be injured. Safety chains have now been installed on all canning jacks to prevent vibrators from falling into the AlSi. This chain also prevents the basket from completely dropping into the furnace. As approximately fifteen canning baskets have failed recently, Maintenance Engineering is continuing an investigation to determine the cause of the basket failures. Recently several modifications have been made to correct the problem. Results of these modifications are not yet conclusive.

Sufficient amounts of satisfactory components from one vendor are now on hand to make a second production run of this material. It is understood that the balance of the 80,000 components will be on-site by December 1. Roughly 12,000 pairs of spires and cans have been received from a second vendor. These look very good and are comparable to the currently acceptable material. If the quality remains good and delivery schedules are met, this second vendor may prove competitive.

The ultrasonic welder was accepted by Manufacturing on November 1, 1960, and has been operated daily on one shift since that date. At month end the equipment is performing satisfactorily. As was reported previously, the hydraulic pressure was improved to decrease the cycle time, and conversion was made to facilitate welding three-rail, instead of four-rail, projection elements, both of which have increased the capacity of the machine. A longer evaluation period will be required to establish yield and efficiency "norms" for ultrasonic welding, but the initial results have been encouraging.

306 Pilot Plant

A total of nine development tests were conducted in the 306 Pilot Plant during November. The largest test was a 10,000 piece demonstration of the proposed projection element finishing process flow. No problems were immediately apparent in processing these pieces; however, data is still being evaluated regarding the various phases of the program. Included in the November Pilot Plant test schedule were investigation of the 4-inch I & E canning cycle, canning in nickel plated components, evaluation of bottomless sleeves, comparison of submerge and spray type degreasers, and DC welding studies.

305 Test Reactor

Routine production testing continued to remain in a current status throughout November. As a result of careful scheduling, approximately 28 per cent of the reactor operating time was made available and was utilized for special testing. Six special tests were completed measuring the purity of graphite bars, most of which were associated with the NPR program. One test was conducted to measure the "poison" level of enriched LiAl samples.

OPERATING PLANS

Fuel Element Performance

A modification was made during the month to data collection and presentation methods in an effort to gain a more accurate and timely picture of manufacturing performance and quality characteristics of uranium fuel elements. In general, the presentation of measurements was expanded from a daily and monthly summary of over-all manufacturing yield and reject rates, to detailed performance measures on each fuel element lot. The lot performance measurements are plotted daily on control charts to enable out-of-control conditions to be pinpointed, to show differences in performance and quality resulting from process changes, and to show trends in performance. The control charts are located in the manufacturing area where they are readily available for inspection.

In addition to the charting, it is planned to summarize and present the performance and quality picture in a written report on a monthly

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basis. Records are being maintained for accumulated performance data on the fuel element lots to be available for use in engineering analyses, particularly as to the effects which process and product changes have on fuel element manufacturing performance and quality characteristics. Initially, these data will be manually processed, but plans are being made to convert the system to electronic data processing. This will result in reduced clerical effort and increased flexibility as to the types of analyses and comparisons which can be made regarding manufacturing and quality performance.

Spire Pulse Preheating

Previous testing of the spire pulse preheating technique has shown resultant quality improvements and some indication that spire etching may not be required with this technique. Elimination of spire etching would result in both capital and space savings. The purpose of this test was to determine if spire etching could be eliminated without incurring a reduction in spire wetting.

One hundred pairs of spires were run and evaluated. A pair consisted of one etched, pulse preheated spire and one nonetched, pulse preheated spire. Of the 100 pairs, 27 pairs showed nonwetting. Of these 27 pairs, 23 pairs were favorable to etched pulse preheated spires. This difference in nonwetting was statistically significant and indicates that etching should be incorporated with spire pulsing at the present time. More work needs to be done to optimize the spire pulser. This would involve determining the optimum strength of the spire pulser spring when using the modified tongs and tong holder. The modified tongs and tong holder were designed by Process Engineering to decrease whipping of the tong during pulsing.

It is expected that in the near future another test will be run, in which pulsed, nonetched spires are used in assembling fuel elements. The extra washing action of the canning process and the effects of the optimized spire pulser will be evaluated in terms of spire wetting to determine if spire etching is necessary.

Coextrusion Recovery

Facilities Engineering has proposed that uranium recovery from coextrusion process solutions be done in the 313 Building. To do so would increase the solutions throughput two-fold. An engineering study of the filter press capacity and its utilization is being made. Shortly, we will have determined whether the filter press capacity is adequate to take care of the increased throughput or whether it will have to be replaced with a larger size press. As a part of this study, a complete analysis of the methods used in the recovery process and equipment utilization is being made.

Chemical Milling

Development work in the chemical milling process has been hampered by the lack of suitable baskets to test chemical milling in the horizontal position. A rotating chemical milling basket which holds fuel elements in the horizontal position has been designed and fabricated. Limited testing has been done with this basket. Even so, the results are most encouraging. It has cut the chemical milling time in half and provided a more uniform surface. Currently the basket is being adapted to be driven by a variable speed motor to permit the speed of rotation to be varied. Horizontal rotation is expected to reduce greatly the process time and the problems associated with uniform milled surfaces.

EMPLOYEE RELATIONSSafety Performance

Members of the Manufacturing Operation were treated for 19 medical treatment injuries during November, a frequency rate of 3.02.

Radiation Control

For the four week period ending October 7, 1960, Manufacturing personnel received a combined total of 7,785 mrad of radiation exposure. Only one individual exposure in excess of 300 mrad was recorded.

Security Violations

There were no security violations in the Manufacturing Operation during the month.

Training

During November the exempt personnel of Quality Control Engineering completed a short course in electronic equipment. The course was comprised of two parts, viz; (1) theory of operation of several basic circuits and circuit components, and (2) block diagrams and methods of operation of all nondestructive testers presently in use in FPD. In addition, the design parameters of the NPR testers and the Bond Integrity Tester (UT-4) were outlined.

Reports of Invention

All persons engaged in work that might reasonably be expected to result in inventions or discoveries advise that, to the best of their knowledge and belief, no inventions or discoveries were made in the course of their work during November.

Wm Mathis
Manager - Manufacturing

WM Mathis:HFT:gl

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STATISTICS

1959 - 60

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ENGINEERING OPERATION

November, 1960

VISITORS

	<u>Company</u>	<u>Contact</u>	<u>Date</u>	<u>Reason</u>
DR Jefferson TJ Graf	Bridgeport Brass	SM Gill GW Riedeman	11/9- 11/10	Discuss NPR developments.
SW Parembka	Battelle Memorial Institute	TB Correy	11/11	Discuss pressure bonding process.
J Morris	Vacu-Blast	WG Hudson	11/15	Discuss vacu-blast equip- ment and set up perform- ance testing.
K Hubbard	Mallinckrodt	G Waldkoetter	11/28- 11/29	Discuss UT-2 Project.

TRIPS

DC Worlton	Cleveland, Ohio	---	11/9- 11/11	Attend ultrasonic forum on the nondestructive testing of zirconium.
JT Stringer	Mallinckrodt National Lead of Ohio	JA Fellows FL Cuthbert B Metz	11/29 12/30	Visit feed sites, dis- cuss U technology,
WG Hudson	Precision Eng'g. Corp.	J Morris S Luft	10/29	Observe and evaluate vacu- blast process and equip- ment for NPR fuel element application.
	Vacu-Blast Corp.	S Finn W Mead	10/31- 11/1	
GW Riedeman SM Gill	Bridgeport Brass	L Menns	11/7	Conference on NPR fuel assembly components.
	Harvey Aluminum	GA Moudrey	11/8	" "
GW Riedeman	Wah Chang	R Graham	11/15	Source development for N Reactor fuel supports.
	Oregon Brass Works	W Prier	11/16	Discussions on copper billet fabrication.

TRIPS (Continued)

	<u>Company Visited</u>	<u>Contact</u>	<u>Date</u>	<u>Reason</u>
WA Hendricksen	U.S. Chemical Milling	D Atkins C Vinton	11/8- 9-10	Discuss progress on development contract and plan future approaches to solve the problems in milling.
LH McEwen	National Lead Mallinckrodt GE - Engr. Ser.	LE Cuthbert J Fellows J Mays	11/30 11/29 12/1- 2	Discuss uranium at NLO and MCW.

PERSONNEL

<u>Name</u>	<u>Title</u>	<u>Operation</u>	<u>Nature of Change</u>	<u>Date</u>
LH McEwen	Manager, Engineering	7050	Trans. to 4400	11/1/60
DH Lund	Secretary	7050	Trans. to 4400	11/28/60

INVENTIONS

All Engineering Operation personnel engaged in work that might reasonably be expected to result in inventions or discoveries advised that to the best of their knowledge and belief no inventions or discoveries were made in the course of their work during November, 1960 except as listed below. Such persons further advise that for the period therein covered by this report, notebook records, if any, in the course of their work have been examined for possible inventions or discoveries.

G. R. Hanson	A Self-Aligning Welding Chuck For Cylindrical Fuel Elements, 11/28/60.
I. V. Nelson	Inert Gas Welding Torch with No Seals on Water and Gas
D. C. Worlto	A Method of Insuring the Integrity of Welds Made by Ultrasonic Welding Techniques, 11/15/60.

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COEXTRUDED PRODUCT ENGINEERING

NPR Fuel Development

Fuel Element Fabrication

Two fuel element charges, each containing four 1.6% enriched K-single tube fuel elements, 1.75-in. OD x 1.05-in. ID x 18-in. long were completed during the month and charged into KER Loops No. 2 and 4. These are being irradiated to exposures of approximately 1,000 and 3,000 MWD/T with the lower exposure probably being completed in late January. These are the first essentially prototypal fuel elements charged in the KER loops, in that they have been double salt bath heat treated and have the zirconium: beryllium end closure. It is planned that fuel element operating conditions will represent those anticipated for the NPR outer tube. Additional fuel elements being completed and which will be ready for charging in early December include ten 1.6% enriched K-single tube and three natural K-single tube fuel elements to be used with the thermocouple assembly scheduled for Loop 1. Also, a quantity of N inner tube natural enrichment pieces are being fabricated for the next open loop. These should be ready by mid December.

Materials Development and Procurement

Uranium

Two uranium billets containing 500 PPM silicon were extruded during the month. It has been anticipated that the silicon additions would provide sufficient grain refinement to improve the coextruded product surfaces. The anticipated grain refinement did not result and predictably improved surface conditions did not result either.

Zirconium Components

Progress was made during the month on the vendor evaluation program. Allegheny Ludlum, with a fixed price order, is already fabricating zircaloy cladding shells and first deliveries should be made early in January 1961. Harvey Aluminum has signed a contract on a maximum price-price redetermination basis and should have processed sufficient quantities for price redetermination by the end of January 1961. Agreement has been reached with Bridgeport Brass Company (Riverside, California) regarding their pilot order for zirconium cladding shells. The maximum price-price redetermination contract should be signed within the next few days.

All quotations on cladding components for the billets for the zircaloy clad and enriched I&E program for K reactor coextruded fuels were unsatisfactory. Consequently, this material will be procured as hot extrusions and these will be machined at HAPO. Material will be available for this program on time.

The currently most critical item of zircaloy is the slightly less than 6-in. outer cladding for N-inner tubes, K-single tubes, and K-I&E enriched program. An order for hot extruded tubing (137 ft.) is being completed at Harvey Aluminum and should be at HAPO by December 10. This will relieve all pressure in the foreseeable future on this size of tubing. Progress is being made on the manufacture of the slightly over 7-in. size tubing on this order also. This has been hot extruded to approximately a 9-in. diameter and will be cold drawn to finish ID size. Delivery is scheduled for January 1961.

Extrusion

Zircaloy Cupping for N Inner Tube Outer Clad

Four outer clad zircaloy shells for N inner tube billets were made during the month by cupping in the 6.070-in. liner. Three shells were made with approximately 16 inches of usable length each. The first shell stalled however and gave only eight inches of usable length. Stalling of this cup was caused solely by low billet temperature and no further difficulty was encountered when the temperatures of the remaining billets were raised 150°F.

Experience gained from the above four cups will allow design of tooling for cupping of outer clad components up to 18 inches in length with the 6.070 inch and 7.600 inch liners.

Billet Assembly Variables

To determine the effects of cleaning and assembly techniques on bond and interface cleanliness, a series of KER inner tube billets (total of eleven) were assembled with varying conditions and extruded. Some of the most significant facts which were determined in this test are as follows:

- a. Etching of the zircaloy components produced a cleaner interface than the standard cleaning procedures.
- b. Altrex cleaning of zircaloy components did not make a significantly cleaner interface than components which had been degreased only.
- c. Interface cleanliness ratings of tube extruded from billet assembled thirty days prior to extrusion compared almost exactly with ratings of tube extruded from billet assembled eight hours prior to extrusion.
- d. Interface cleanliness varied only slightly with tubes extruded from billets which were evacuated and billets which were sealed air tight without evacuation.

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- e. Press speed (15 to 30 in./min.) and billet temperature (1150°F to 1200°F) did not have a measurable effect on extruded tube grain size for this particular tube geometry.

Extrusion Program

The following extrusions were made during the month:

7.6 Inch Tooling

- a. Two zircaloy-2, Zr #25 and 26.

Zr-25 - NPR-OT Inner Clad
Zr-26 - 4-in. Solid

- b. Two uranium, U-12 and 13 for NMI heat treating studies.
NPR-OT reject billets were used for both extrusions.

6.0 Inch Tooling

- a. Five composites, T-86, 87, 88, 89 and 90

T-86 and 87 - KER-ST, 1.6% Enriched
T-88 - KER-ST, Normal
T-89 and 90 - NPR-IT, New size using cupped outer zircaloy components.

- b. Five zircaloy-2, Zr-21, 22, 23, 24 and 29

Zr-21, 22, 23 & 24 - Cups for NIT outer clad
Zr-29 - Outer zircaloy tube for NIT loop charging

4.0 Inch Tooling

Eleven composites - T-75 through T-85.

This was KER-IT material to evaluate variables in billet assembly and extrusion conditions.

Chemical Milling

Tentative control limits were established for the chemical milling etchant as follows:

Cu	300-350#	per	1000	Gallon
NO ₃	1000-1300	"	"	"
SO ₄	4400-4600	"	"	"
U	200-1200	"	"	"

A basket and procedure was designed which permits milling both ends of the tube simultaneously. This is a ferris-wheel type arrangement which holds the tubes in a horizontal position while rotating the pieces through 360° at the desired angular speed. A substantial number of samples have been successfully chemically milled in the ferris-wheel arrangement to the specified recess of .270 inches $\pm$.010 inches, and at increased etching rates over the older methods. Advantages of this method are:

- a. Both ends are milled simultaneously.
- b. The milling operation is less sensitive to the solution composition.
- c. Smoother surfaces are produced than with previous methods.
- d. Very little pitting is produced on the uranium surface.

End Closure Brazing

The following items were brazed during the month:

1. Thirty NPR outer pieces 5-in. long
2. Thirty NPR inner pieces 5-in. long
3. Nine NPR inner pieces 13-in. long
4. Twelve KER-ST enriched 16-in. long
5. Six KER-ST natural 16-in. long

A substantial number of the NPR outer pieces showed porosity under the brazed cap on one end of the short piece. It is thought that the pieces were removed from the inert atmosphere too rapidly after the first brazed end had been completed and that this caused the porosity to occur on the other end. Normally during the process using a long piece, the end not heated by the induction coil is not heated because of its distance away. With these short pieces, it is quite possible that the other end, already chemically milled and prepared, became slightly oxidized upon exposure to the air in removing to rotate the piece.

It was demonstrated that the white oxide on the weld bead and braze metal of the KER-single tube enriched pieces fabricated last month was due to improper etching. Use of an aluminum:nitrate stop bath after etching and careful rinsing will eliminate the white oxide problem.

Bids were received during the month for braze rings of the Zr-5% beryllium alloy. For 6,000 rings, the bids varied from about \$17,000 to \$48,000.

Salt Bath Beta Heat Treating

Recent work has been directed at determining how warp can be minimized in the beta heat treated sections of the NPR inner tube. It had been assumed that the final alpha structure in the uranium would be determined by the transformation mechanism on cooling. If so, beta heat treated dimensions versus warp would show some correlation. It was believed that warp would result during quenching as a consequence of variable wall thickness, with the warp concave to the thinnest wall section. Of nineteen pieces heat treated and studied, nine did not agree to this hypothesis. It is concluded that this is not a basic correlation.

The nineteen pieces above were quenched from a chloride salt bath into a nitrate-nitrite salt bath. Subsequently, seven were cooled in water and twelve in air. Warp measurement results after these treatments showed the following.

1. Seven pieces, water cooled; warp - mean 29 ± 8 mils, range 16 to 36 mils
2. Twelve pieces, air cooled; warp - mean 53 ± 43 mils, range 6 to 135 mils

Inasmuch as there is overlap of the standard deviations of the means, the conclusion is that the cooling rate has no effect on the warp.

From the foregoing work, the warp mechanism was not clarified. It thus appeared that a characteristic of the alpha extruded material could be the cause of warp. Of these characteristics, asymmetrical residual stresses resulting from non-uniform cooling were thought to be the most important. These stresses could result from:

1. the contact with the cooling bed (i.e. press runout table),
2. rough handling during cooling (rolling),
3. variable wall thickness in the as-coextruded stock.

The first two points cannot be easily evaluated. For the third variable, it was felt that warp would result during the heating cycle of the heat treating process as a consequence of variable wall thickness with the warp being oriented with the thinnest wall section on the inside of the bow. Table I, below, shows the as-extruded wall thickness (with copper removed) and prediction of the plane of warp as a consequence of the variable wall thickness.

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TABLE I
PREDICTED PLANE OF WARP VS AS-COEXTRUDED WALL THICKNESS

<u>TUBE NO.</u>	<u>AVERAGE EXTRUDED WALL - (INCHES)</u>						<u>WT</u> <u>(MILS)</u>	<u>PREDICTED PLANE OF WARP</u>
58	.421	.418	.412	.408	.409	.416	13	0° Up - 180° Down
59	.413	.415	.417	.418	.416	.413	5	180° Up - 0° Down
60	.417	.417	.417	.418	.417	.417	1	180° Up - 0° Down
61	.418	.416	.414	.414	.416	.418	4	330° Up - 150° Down
62	.413	.412	.413	.414	.414	.413	2	240° Up - 60° Down
69	.414	.414	.417	.420	.420	.418	6	210° Up - 30° Down
70	.419	.421	.417	.415	.414	.416	7	60° Up - 240° Down

Inasmuch as the wall thickness measurements were made at 60° intervals, a correlation of predicted warp vs observed warp was considered significant if the plane of the warp was within 60° of the predicted plane. Table II shows the results of the prediction and the plane of the warp was correctly predicted in 15 out of 19 cases.

TABLE II

<u>TUBE NO.</u>	<u>OBSERVED PLANE OF WARP</u>	<u>MAGNITUDE OF WARP (MILS)</u>	<u>CORRELATION</u>
58	0° Up	1 at 27	Predicted within 0°
59	180° - 210° Up	2 at 39 ± 4	Predicted within 30°
60	170° Up	1 at 36	" " 10°
61	0° Up	1 at 38	Not predicted (60° away)
61	250° Up	1 at 29	" " (80° away)
62	120° Up	1 at 6	" " (120° away)
69	180° - 225° Up	9 at 62 ± 45	Predicted within 45°
70	340° Up	1 at 51	Not predicted (30° away)
70	0° - 30° Up	2 at 10 ± 2	

The results of this correlation are quite surprising. They lead one to believe that the best cure for warp is a perfectly sized tube and that warp occurs on heating and not quenching. Other observations that have been hitherto explained but tend to support this hypothesis are:

1. Salt bath heated sections that are air cooled from the beta phase show warp of equal magnitude to quenched (water, oil, salt baths) sections.
2. Induction heated pieces are visually observed to warp during heating.
3. The beta heat treating of perfect right-cylinders machined from alpha-rolled rods have warped regardless of the quench medium used.

The last point raises what is probably the real cause of warp. Geometry is not the effect; preferred orientation is the effect. The right

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cylinders come from highly anisotropic metal (imperfect rounds with a cruciform pattern from water-cooled rolls). Like the as-coextruded tubes, non-uniform circumferential textures that result in imperfect sections are the driving force for warp.

End Closure Welding

Brazed Closure Welding

Autoclave tests to date do not indicate any difference in the surface of the welds produced by the high and low current techniques. Internal examination of the high current welds shows what appears to be beryllium segregation between the grains of the Be:Zr grains. The segregation is in a branching pattern that starts at the braze and extends into the weld occasionally to essentially the surface of the weld. Weld section specimens are being prepared for autoclaving to determine if there is preferential corrosion of the segregated material. They are to be placed in the autoclave on 11-29-60. A study is in progress to determine the analysis of the segregated material.

All closure welds for material scheduled for the reactors is welded with the high current technique because of the reduced welding and cooling times.

Unbonded Closure Welding

The development of the unbonded closure, a potential backup technique, is virtually complete. The current technique uses a cap which is grooved at the mating surfaces to the cladding and results in a weld bead which is smooth and uniform and will not butt against an adjacent fuel element during charging.

Chemical Processing

Approximately 200 coextruded fuel elements of various diameters and lengths for reactor testing and process development have been processed through copper removal and chemical finishing processes. No serious process problems have been encountered. Surface films on the material which has been autoclaved indicates good control in the etching process.

The chemical facility has also been used for processing of material being fabricated by HLO.

Abrasive Blast Cleaning

Considerable difficulty has been experienced in vapor blasting the internal surfaces of NPR inner tubes. Nozzle plugging and other equipment problems have contributed to the problem.

An alternate process to replace the vapor blast has recently been investigated and evaluated. This method uses a dry abrasive which is air blasted against the clad surfaces through specially designed internal and external nozzles as in the vapor blast process. This method has been demonstrated to produce complete oxide removal up to 18-in. a minute on the smallest ID tube as compared to about 2-in. a minute with the present vapor blast equipment. A more complete description of this process is contained in HW-67405, "Process Criteria, Zircaloy-2 Clad Oxide Removal". An appropriation request has been prepared to procure the necessary equipment utilizing this process to replace the existing vapor blast machine.

Autoclave

Three charges of KER single tube were autoclaved for reactor testing. A dual water and steam cycle was used in each charge. The 36-hour, 400°C and 4500 psi steam test was supplemented by two and three day water test at 350°C and 2250 psi.

All elements discharged indicated satisfactory corrosion properties for reactor charging.

Side Support Attachments

Stud type side supports have been installed on all material to date used for reactor testing of KER single tube type fuels. A metallographic study was made of the studs and it was found that reproducibility of good welds was accomplished with a very slight alteration in the cladding to core bond width and uranium grain size along the bond interface. Penetration of grain size change into the uranium was very small.

On 11-18-60, the decision was made to use zircaloy-2 side supports with steel saddles on the NPR outer tube. A statistical sample of the welds has been made for metallographic examination.

Testing and Inspection

Ultrasonic and Eddy Current Testers

Testing of brazed end closures in the pilot plant was started this month. The equipment is still in the laboratory stage and each piece has to be run several times. Three groups of pieces have been tested. Two groups of KER-ST pieces gave only a few signals. One group of 5-in. long NPR-OT pieces gave large signals from the cap-core bond and the cap-clad bond. Destructive testing showed large voids and non-wet areas were present. This group of material shows the need for nondestructive testing of brazed end closures for the I&E program.

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Good clad, bond, and braze standards have been prepared for KER-ST and NPR-IT sizes, and good braze standards have been prepared for the NPR-OT size. Clad and bond standards for the NPR-OT cannot be made until material with the correct clad thickness is coextruded.

A nondestructive test for uranium grain size was made on a 500 ppm silicon billet. Large grains were found on the OD surface. The grains were large enough to predict a rough surface on the coextruded tube. The tube coextruded from this billet was rejected for surface roughness.

Defects in Bore of Coextruded Tubes

Several serious looking defects in the bore of coextruded tubes have been found. These defects appear as a groove that follows the lines in the extrusion pattern. The most serious looking defect was found in NPR-OT. The clad in one spot on this tube was less than 50% of the nominal clad thickness. These defects may be caused by machining defects in the inner zircaloy clad component.

Cap Thickness

IPD has requested a minimum cap thickness of 0.200-in. The present cap thickness before facing is 0.220-in. This means the cap would have to be faced to $0.210 \pm .010$ -in. With the variations in the rest of the process, it would be very difficult to face this limit on a production basis. As soon as possible, fuel elements should be faced using the technique planned for production use. Then, the variation in cap thickness could be measured and the amount the nominal cap thickness needs to be increased could be determined.

Equipment

Billet Induction Heating

Minor Construction has completed the installation of the billet induction heating transformer, work coil, and control hookup. Plans are to heat the first billet early in December.

End Closure Machining

The lathe in the 333 Building has not yet been used for machining the end closures after brazing and heat treating. To date, work has been accomplished on scrap pieces of zircaloy. First test machining should take place about the second week in December. In preparation for this, the following equipment modifications to the lathe were made:

1. A plexiglass box shield was designed and fabricated for the lathe.
2. Three tool holders and one positioning bar were designed and are now being fabricated.
3. Two form cutting tools for NPR tubes and two form cutting tools for I&E tubes were designed and are now being fabricated.

I&E Welding Equipment

The inert gas welding chamber has been completed. The horizontal welding assembly will be completed on schedule as the milling machine and gear head motor have arrived. The milling machine will be used for a torch support and also to provide the necessary movements desired for the torch.

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ALSi PRODUCT ENGINEERING

Fuel Performance and Requirements

Ten natural uranium fuel elements (eight I & E and two solid) and one I & E enriched fuel element failed in the reactors during November. A summary of these ruptures is shown below:

<u>Fuel Element Type</u>	<u>Reactor</u>	<u>Exposure (MWD/T)</u>	<u>Rupture Classification</u>	<u>Canning Date</u>	<u>Cladding Alloy</u>
I & E Natural	B	662	Side Hot Spot	6/1/60	X-8001
	B	500	Side Hot Spot	8/1/60	X-8001
	B	633	Side Other	7/28/60	X-8001
	C	651	Internal	4/12/60	C-64
*	D	635	Side Other	1/7/60	C-64
	F	599	**	5/25/60	X-8001
	KE	532	Unknown	8/10/60	X-8001
	KE	667	Internal	8/17/60	X-8001
Solid Natural	DR	457	Core Split	7/7/60	X-8001
***	DR	614	Core Split	5/9/60	X-8001
I & E Enriched	KW	668	Side Hot Spot	7/13/60	X-8001

* Water mixer fuel element

** Not examined

*** Two fuel element ruptures sustained in same process tube

A less favorable rupture trend was indicated this period. Both of the natural I & E internal ruptures are assumed to be fuel element quality oriented since previous examinations have confirmed that this type of rupture is generally caused by defective end closures. The internal rupture experienced in KE Reactor may also involve ingot uranium having an excessively high iron content (~600 ppm), which was inadvertently used to fabricate HAPU fuel cores by the producer site. Small cracks observed on the surface of a recovered core lead to the detection of this material and subsequent rejection of 78 cores. However, some of the cores had been reactor charged before the problem was recognized. The ruptured piece is scheduled to be examined in the Radiometallurgy Laboratory to determine cause of failure and condition of the uranium core.

Film patterns on the I & E water mixer rupture classified as side other, indicated the piece had rolled against the process tube wall, which presumably contributed to localized corrosion attack and penetration of the fuel element jacket. The I & E side hot spot ruptures are attributed to fuel misalignment and warp.

A total of 81 columns of self-supported I & E fuel elements has been irradiated to goal exposures up to 1200 MWD/T. No hot spots have been observed; however, hot areas extending around the external central surfaces have been noted on

several fuel elements. Three pieces having hot areas are being examined in the Radiometallurgy Laboratory to determine the extent of surface corrosion.

Irradiation of I & E bumper fuel elements continues on limited schedule pending the development of satisfactory reactor charging equipment. Only 24 columns of natural I & E bumper fuel elements are currently being irradiated in D Reactor, and 23 columns have been discharged without incident at goal exposures up to 960 MWD/T. Approximately 50 tons of natural I & E fuel elements with solid bumper rails were prepared during the month for reactor charging.

Examination of three self-supported I & E fuel elements, having bumps on the internal and external surfaces up to 30 mils in height, in the Radiometallurgy Laboratory is essentially complete. These fuel elements were exposed to about 850 MWD/T in C Reactor. Metallography has indicated large preferentially oriented grains in the uranium cores contributed to the surface bumping observed on two pieces. Unusual corrosion caused an irregular wavy jacket surface on the third piece. Minimum residual jacket thickness on this piece was in the order of 20 mils. Examination of unirradiated cores from the same ingot lot (KTL-004) confirmed the presence of large grains in the uranium.

Uranium Technology

Approximately 176 tons of alloyed dingot uranium are currently being irradiated; about 163 tons have been discharged to date. There were no dingot failures during the month; only three failures have been experienced to date. About 5, 29 and 18 tons of regular virgin, vacuum outgassed virgin, and recovered dingot cores, respectively, were canned during the month. Since the irradiation performance of dingot uranium is not significantly different from ingot uranium, dingot uranium cores will no longer be segregated from ingot cores in recovered, reprocess, and miscellaneous lots. Incoming lots of virgin dingot cores will continue to be segregated and identified.

Alloyed dingot uranium canned during the month had a larger grain size than previously received dingot cores. The large grain reject rate through the UT-2 testers was about 17 percent, as compared to less than 0.5 percent for previous dingot material. MCW personnel believe that this increase in grain size is due to a decrease in the amount of silicon added to the uranium. The silicon content currently falls between 85 and 100 ppm, as compared to a previous range of 110-130 ppm. Although MCW is increasing the silicon content of dingot uranium to reduce grain size, about two months' production of large grain material is in the process stream. The bond test reject rate for virgin dingot cores increased about 4.0 percent over last month's rate to 9.4 percent; this compares to a reject rate for virgin ingot cores of 4.0 percent for lots canned just before and after the canning of dingot uranium. Since the majority of the dingot cores were fabricated from vacuum outgassed material with a total hydrogen content of less than one percent, the observed increase in braze porosity is believed due to surface hydrogen picked up during salt bath beta treating at the producer-sites during the high humidity months of August and September.

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Cores with severe quench cracks (up to 0.248" deep) on the outside surface were found at core pickle inspection in material from two natural and two enriched ingots. The quench cracks resulted from high iron contamination (533 to 628 ppm Fe) that was not detected at NLO before rolling. Hypereutectoid concentrations of iron are known to produce severe cracking during quenching due to formation of the brittle U_6Fe phase. The first quench cracked core was found in a recovered lot and was quite apparent due to the localized attack of the cracks during the caustic recovery and acid pickling operations. However, the thin cracks in virgin cores were not easily discernible and some of the cores (only 78 were found) from the aforementioned ingots were accepted and charged in the reactors.

A test quantity (1078 pieces) of low hydrogen alloy dingot uranium CVIN cores for the overbored C Reactor test program has been received. These cores were fabricated from alpha extruded tubes. Examination and testing of this material is in progress. NLO has reported some small internal surface cracks were observed in the core blanks following beta heat treating, which may adversely affect the quality of the finished cores.

Process Development

Post-irradiation examination of chemical-nickel plated fuel elements irradiated to approximately 800 MWD/T revealed no sloughing of the nickel plate; thus it appears that methods employed for improving and testing plate adhesion were effective. However, a possible deficiency still exists in that hairline cracks developed in the nickel plate on 18 of 560 pieces irradiated. It was observed that the cracking preferentially occurred on the cooler regions of the surface between 0 and 90° from the rib marks. No cracking or corrosion was observed in or near "hot spots". Radiometallurgy examination is scheduled to further characterize and assess the effects of the nickel cracking. Further, since low ductility may limit the integrity of the nickel coating, efforts are underway to produce a more ductile plate by reducing the phosphorous content.

Sixty-four (64) chemical-nickel plated fuel elements were discharged from the Poison Column Displacement test after being irradiated to goal exposure without incident. Two columns (32 slugs) remain in KW Reactor. Ex-reactor corrosion tests of chemical-nickel plated slugs in 120 C and 165 C process water flow tubes continued, accumulating approximately 20 weeks' exposure.

A total of 219 fuel elements was canned by a modified lead-dip process in chemical-nickel plated components with only minor problems in assembly, and bond test rejects were less than 1.0 percent. Stud-pulling and jacket-stripping tests indicated the jacket-core bond was generally as strong as normal production material. Metallographic examination of jacket sections indicated that a 0.5-mil thick inner nickel layer is not penetrated by the AlSi, while 0.1-mil thick nickel is penetrated with rather uniform dissolution of the can wall to a depth of two to four mils. Further tests are being made to determine if 0.2-0.3 mil thick nickel deposited on the inner wall of the components will resist AlSi penetration.

Incentives for nickel-plating aluminum-jacketed fuel elements were re-evaluated. Potential benefits include reduction of fuel element rupture rates, reduction of aluminum can-wall thickness with concomitant increases in uranium volume and/or water passage cross-sectional area, and greater latitude in process water treatment and reactor decontamination procedures. These amount to substantial incentives with or without addition of projection rails. Further details will be published in the near future.

The prototypic ultrasonic welder for attaching projections of fuel elements was operated satisfactorily by Manufacturing personnel throughout the month, producing approximately 50 tons of natural I & E three-rail bumper fuel elements for the D Reactor demonstration loading. The welder operated at about 95 percent efficiency with the capacity approaching the targeted design goal of 200 fuel elements per hour. Major reject categories and reject percentages were as follows:

Incomplete Welds	3.2 Percent
Rail Misalignment	1.8 Percent
Marred Surface	1.0 Percent

Incomplete welds are caused primarily by a malfunction of the welder. This problem results from the welder transducers being mounted on sliding ways to facilitate movement of the welding tips away from the fuel elements and to transmit the welding pressure. If the sliding ways become loose to the point that the vibrating reed transmits little or no energy to the projection rail, the weld will be defective or incomplete. Although it has not been possible to eliminate this problem, rewelding is feasible to minimize these rejects. Misalignment of the rails may be further reduced through improvement of the rail feed mechanism. Marred surface rejects have been minimized through the removal of an indexing device installed on one of the welder chucks, which has proved unnecessary to prevent slippage of the fuel elements.

Specifications have been prepared for ultrasonic equipment for the first two ultrasonic production welders to be provided under project CGF-903, "Projection Fuel Element Modifications - 313 Bldg. - Phase I".

Evaluation of alternate processes for existing reactor fuels was continued. Plating racks have been designed and are being fabricated to produce fuel elements by the HAPO hot-press process for evaluation. Punches are being developed for the press. Rebuilding of the press furnace block is awaiting delivery of heating elements.

Process Technology

Developmental tests were completed in the pilot plant to optimize canning cycles for "O" size (OVN) four-inch I & E fuel elements, which are scheduled

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to be prepared in production quantities for old reactor fringe loadings early next year. Optimum cycle times determined for core preheat and agitation in the lead and AlSi layers of the duplex canning bath were 24 and three seconds, respectively. The optimum can-sleeve preheat time in the canning bath was observed to be 65 seconds. Based on test data these cycles are expected to yield an average external bond count of about four and an internal bond count of eight. Average external bond strength will be in the order of 15,500 psi

Core heating rates in the duplex canning bath were determined for oversize (1.893" O.D. and 0.452" I.D.) I & E cores to be used in the preparation of CVIN fuel elements for the C Reactor overbore program. Temperature measurements taken by embedding thermocouples in prototypical cores indicated a duplex cycle time in the order of 35-50 seconds will be required if lead plugs are inserted in each end of the core. Without lead plugs, the cycle time will approximate 75 seconds. The lead plugs prevent AlSi from flowing inside the core and freezing during submersion in the duplex bath, thus increasing the core heating rate and lead-uranium reaction time on the inner core surface. Extension of the lead-uranium reaction time produces a compound layer on the internal core surface more nearly equivalent in strength and quality to the external compound layer.

A preliminary test was run to determine the effect of fuel element facing methods on weld quality. Four groups of 200 fuel elements each were faced using standard techniques, a step cut, a braze groove cut, and a relief cut. The fuel elements were welded, etched, and inspected for defects. All of the latter methods appeared to be somewhat better than the standard method, but additional tests are required to verify the small differences observed.

Vertical spire-pulsers were received for installation on all production canning lines. Installation was completed on one line at month end, and is scheduled at the rate of one line per week. Use of this equipment will improve spire wetting and remove gases normally trapped underneath the cap wafer.

Fabrication of a prototype pressurized quench machine was completed. Installation in the pilot plant is scheduled to be completed by the second week in December for testing and evaluation.

The development of suitable tooling for machining four-inch I & E "N" pieces was completed. In addition, installation of a DC welder was also completed for welding the end closures of canned I & E "N" pieces. With the completion of these two items, it should be feasible for Manufacturing to begin producing this material for the proposed full reactor E-N demonstration loading early next month.

Design and fabrication of pilot plant and 313 Building equipment to produce the initial test run of oversize I & E (CVIN) fuel elements for the C Reactor overbore program is essentially complete. Process development for producing this material is in progress.

306 Pilot Plant Activities

The 306 pilot plant facility was used during the month for a large-scale demonstration test of the proposed process flowsheet for projection fuel elements. The proposed flowsheet consists of DC welding fuel element end closures followed by bond-penetration testing, caustic-detergent etch, weld closure inspection, soap dip, rail attachment by ultrasonic welding, hot water rinse to remove soap film, autoclave testing, final inspection, and radiography. Approximately 7000 OIIN I & E fuel elements have been processed and the remaining 3000 fuel elements will be completed the first week in December. Results of the test have been favorable with no serious problems being encountered.

In order to determine the effect of sonotrode force on ultrasonic rail weld quality, a test was made varying the force in increments of 100 pounds from 200 to 600 pounds. Sixty-four welds were produced for each increment of force for testing weld strength. It was concluded from the data that sonotrode force has little effect on weld strength or quality. A force of 400 pounds yielded the highest average tensile strength and the smallest standard deviation.

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TESTING METHODS

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Process Fuel Element Testing

Bare Core Station

Circuits built into the UT-2 stations for the purpose of detecting cracks, seams, and striations have been placed in operation on one production line unit. Digital information corresponding to the total integrated length of these defects is being automatically read out for each core, although pieces are not being actually segregated as yet. These data will be logged on the prototype data logger for about two weeks in order that appropriate rejection levels may be determined.

New circuit boards which more accurately measure ultrasonic attenuation in large grain cores have been completed and installed in all testers. Check-out tests have shown these circuits reproducible from station to station. Their improved performance has been confirmed by destructive examination of rejected pieces.

N Reactor Fuel Element Inspection

Confidence in the ultrasonic closure inspection test was strengthened this month by a test in which bonafide braze layer defects were found in seventeen of a group of twenty-five elements. These pieces were of short length but otherwise fabricated by standard processes. Signals indicative of gross braze layer porosity were received on the defective closures and confirmed by destructive examination. These types of indications have not been observed on similar tests of other N Reactor fuel.

Testing a group of ten elements prior to reactor charging showed that the sensitivity of the cladding thickness test is sufficient to clearly show the reduction in cladding thickness (approximately three mils) affected by the etching process.

Fabrication of the electronic portion of the first production facility test station is nearing completion. Design of the second test station has become firm. Orders for on-site fabrication of the second station have been placed.

Recent laboratory tests have confirmed the ability of the ultrasonic billet test to recognize variations in grain structure. The effect was most pronounced on a particular billet whose ultrasonic attenuation was some three times greater than that observed in other billets. When extruded, this billet produced fuel whose outer zirconium surface was so rough as to be entirely unsatisfactory.

New Methods Development

Closure Inspection

Recent tests have disclosed that two separate tests, one employing shear waves and the other longitudinal waves, are required to completely inspect the closure zone of process fuel elements. Accordingly, circuitry has been developed and put into operation which enables the prototype tester to perform both of these tests simultaneously. A preliminary test of the modified equipment rejected about seven and one-half percent of four-hundred pieces. Four percent of these were rejected by the longitudinal test which was set to reject a fabricated defect one thirty-second inch wide, and the remainder were segregated by the shear wave test which was set to reject a fabricated twenty mil diameter hole extending from weld bead to uranium core.

Destructive examination of these pieces is now in progress. Fabrication of production testers will be initiated as the performance of the prototype is determined to be satisfactory.

N Reactor Fuel Cladding Tests

"Normal" zirconium extrusion marks produce eddy current noise signals which tend to mask signals from bonafide cladding defects. A technique which appears to significantly reduce the severity of this inherent limitation of the eddy current test has been developed. Two identical inspection coils are placed side-by-side on the surface along a line parallel with the longitudinal axis of the fuel element. The coil outputs are connected in opposition to cancel the effect of extrusion deformations. Present laboratory arrangements clearly reveals a one thirty-second inch diameter cladding defect in a sample whose surface is exceptionally rough. Efforts are under way to further improve the resolution of this technique.

Laboratory work on a prototype ultrasonic weld monitor is complete. The instrument is designed to recognize abnormalities in the electrical energy flow to the transducer which result when unsatisfactory welds are made.

Preliminary evaluation studies made on the automatic ultrasonic welder indicate, however, that additional development work will be necessary to make the technique applicable to routine operation. A difficulty which must be overcome arises from the dissimilar operating characteristics of the four welding heads.

Lamb Wave Testing

Investigation is continuing on the study of wave propagation in small diameter tubing as compared with Lamb waves in thin plates. The similarity of results indicates this may be the same wave motion. By using a narrow frequency range and a fixed angle of entry, reflections of the Lamb waves from defects have been observed similar in most respects to the tubing

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signals. At certain angles and frequency depth products, the return amplitude is proportional to defect size. At others it appears to have no or inverse correlation. To study this further, an r.f. gate was constructed so as to isolate for frequency analysis discrete return pulses. Also, plates with milled notches are being obtained for study.

At the request of Hanford Laboratories, work has begun on design of an advanced ultrasonic inspection station for thin-walled tubing. Four separate tests are to be included in order that defects may be reliably detected regardless of their orientation within the tube wall. The station will also measure and record the wall thickness of each tube.

ENGINEERING GENERAL

Hanford Test Reactor

Routine testing continued without incident throughout the month. A graphite testing procedure was provided for testing 2" x 3" x 48" bars.

Asymmetrical Power Measurements

The prototype construction and installation is complete. However, no test data has been conducted as yet since there have been several water leaks in the lower shielding. Further work will be delayed until about December 8, 1960.

LH McEwen
Manager, Engineering

LH McEwen:dl

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FINANCIAL OPERATION
NOVEMBER, 1960

A review of project engineering costs incurred on all Department projects completed during the calendar years 1958 thru 1960 was made during the month. Following is a brief summary of these costs on the seven projects completed during this period.

Title I Preliminary Design	\$ 37 165
Title II Design Services	70 131
Title III Supervision of Construction	34 055
Management Services	32 399
Total Engineering	<u>\$ 173 750</u>
Total Project Costs	<u>\$2 122 692</u>
% Engineering to Total Cost	8.2%

The Midyear Review of FY 1961 Plant Acquisition and Construction Budget has been completed and submitted to Contract Accounting for consolidation. Construction expenditures, excluding miscellaneous capital work orders for FY 1961 are estimated at \$3.4 million. The major portion of this amount (\$3.3 million) will be incurred on Project CAF 847, New Fuel Cladding Facility. The balance will be incurred on CAF 894, Increased Air Capacity; CAF 915, Increased Storage Space; and design of oversize fuel element modifications.

Directive No. AEC 183 has been received by the HOO-AEC, Process Engineering and Manufacturing Division, authorizing expenditure of \$80,000 on Project CAF 915, Increased Storage Space - 303 Area. Work authority CAF 915 (1) authorizing GE to incur costs of \$8,200 to provide Title III, related management services, tie-in work, and technical direction of design has subsequently been issued. H. E. Bovay, Jr. will perform Titles I and II design and GE will record and report costs incurred by Bovay.

Eight appropriation requests covering equipment valued at \$116,500 were processed during the month. However, cancellation appears imminent on the \$50,000 request covering procurement and modification of two Acme Gridley lathes which were reported to be excess from other government agencies. Upon placement of the purchase order, it was learned that the lathes were not available to us. At present, it appears likely that request for \$50,000 for one new lathe will be submitted in substitution.

The first purchase requisitions for equipment to be used on Project CAF 915, Projection Fuel Element Modification, have been submitted to Purchasing. Included in the items requisitioned is ultrasonic welding equipment valued at \$90,000. Additional welding equipment valued at \$87,000 will be requisitioned within the next few weeks. Lead time for this type of equipment is about four months.

Travel costs for November were \$9,400. Nine hundred dollars was expended on Professional Society meetings, \$800 on offsite courses and \$7,700 on regular business travel. This brings fiscal year-to-date travel cost to \$23,200.

Travel in FY 1961 is about \$2,100 higher at this point than it was in FY 1960 due to movement of employees and household goods.

One revised HAPO OPG was issued and five new guides were reviewed and made ready for immediate issuance. Comments have been received from all sections in regard to the adequacy and completeness of the OPG system. Need is indicated for approximately six new Department guides.

The initial study phase of the manufacturing process integrated data processing system is complete. Information developed thus far was referred to C&AO Procedures Operation for further action. Efforts in other areas of the over-all study are continuing.

A meeting was held with representatives of the Manufacturing Section, Engineering Section and C&AO Procedures Operation for the purpose of discussing the IPD fuel element identification program and its possible application within, and effect on FPD. Information developed was inconclusive and indicated a need for further action and study. Subsequent developments will be made the subject of a special report.

All FY 1961 Midyear Budget Review schedules were submitted to Contract and Accounting on schedule. Included were the following reports:

1. Personnel Forecast
2. Offsite Contracts - Research and Development
3. Inventories
4. Increases-Decreases from FY 1961 Revised Budget
(Controllable Cost basis)
5. Explanation of Variances from FY 1961 Revised Budget
6. Production Unit Costs

For departmental use, HW-63528, a comparison of FY 1960 Actual, FY 1961 Revised Budget, and FY 1961 Midyear Review was prepared.

Conversion and depreciation unit cost goals for CY 1961 were prepared and submitted on schedule. In addition to the goal submission, a summary of variances was prepared in order to determine differences in cost between CY 1960 Actual and CY 1961 Goals, along with a tabulation of the basic assumptions upon which the goals were based.

A detailed unit cost comparison was made between Savannah River and HAPO operation for the quarter ended September 30, 1960. The comparison covered cost per piece for the fabrication of fuel elements and the cost per gram of Pu Nitrate separated. These costs were segregated into three categories: i.e., feed material, conversion and depreciation.

At the request of Plant Facilities Engineering, a study was prepared which covered cost and quantities of steam generated at HAPO for CY 1960. This information was broken down by month for each of the 100, 200, 300 and 700 Areas.

Several meetings were held with various operating managers to discuss and insure complete understanding of the improved operating cost report format issued last month.

All applicable operating cost reports were reviewed with Engineering and Manufacturing Maintenance administrative personnel to determine their adequacy.

Manager - Finance

WS Roe :mh

PLANT FACILITIES OPERATION

NOVEMBER 1960

I. RESPONSIBILITY CHANGES

None.

II. ACHIEVEMENTS

A. Statistics

1. Duplicating

<u>Process</u>	<u>No. of Impressions</u>
Multilith	484,204
Verifax	11,452
Ozalid	12,106
Total	507,762

2. Utilities

	<u>Nov.</u>	<u>Oct.</u>
Average steam generated (M lbs/hr)	76	50
Maximum steam generated (M lbs/hr)	105	76
Total steam generated (M. lbs)	54,584	37,435
Coal consumed (Tons)	2,595	1,824.31
Evaporation rate (steam/# coal)	10.67	10.26
Efficiency - Actual	69.0	67.3
Efficiency - Theoretical	71.5	71.0
No. of Boilers On: 3 4 5 6 3 2		
Date of Change : 5 8 10 11 17		
Sanitary water from 3000 Area (M Gals.)	121.49	119.76
Total water from 3000 Area (Avg. Rate GPM)	2,812	2,683
Total water from #3 & #4 Wells (M Gals.)	14.21	20.16
Total water from #2 Well (M Gals.)	.30	.30
Peak water consumption for 24 hrs. (M Gals.)	4.4	4.5

B. Operating Experience

The No. 6 Boiler was returned to service on November 11, following completion of the replacement of the blistered water wall tubes, reported in the previous month's historical report.

Several instances of excessive water in the compressed air supply were reported at the 3722 and 3732 Buildings. The air line re-grading and trap revision program was not fully in effect at the time, but has since progressed far enough along so that future troubles are not anticipated.

C. Equipment Experience

Several instances of travel direction reversal have occurred to the grates of the No. 6 Boiler, as a result of worn parts in the hydraulic drive mechanism. Replacement of the parts has been scheduled for December.

The motor on No. 4 compressor was discovered to be misaligned. An inspection revealed that all of the support fasteners had broken off as a result of excessive vibration and cocking, caused by a poor foundation. New spacers were fabricated to permit the use of a through-bolt type of fastener, and the compressor was restored to service at month's end.

The old 3 KVA lighting transformer that was to be used for emergency loads in the 382 Building burned out on November 18. The transformer failed as a result of an overload condition. All 120 volt service in the building is currently being supplied by a new, recently installed 10 KVA (normal power) transformer, pending replacement of the burned-out (emergency power) transformer.

D. Inventions and Improved Methods

All personnel in the Operation engaged in work which might lead to inventions and/or discoveries advised that, to the best of their knowledge, none were made in the course of their work during November 1960.

E. Costs and Savings

Cost reduction items amounting to \$26,250 were submitted during the month.

F. Status of Projects and Major Jobs

3717 Building Sheetmetal Shop Addition - A lump-sum contract was awarded to the R. J. Britton Construction Company for \$13,000. Construction is scheduled to start December 5 and be ready for occupancy by January 11.

384 Building Personnel Facilities - Construction proceeded on schedule, with field construction 55% complete. All concrete work was completed.

Renovation, 303-J Building - The lump-sum contract with J. A. Jones was completed and the building occupied. Design work for the air conditioning and ventilation system has started.

F. Status of Projects and Major Jobs (Cont'd)

North Ground Storage Reservoir Piping Modifications - Field construction proceeded on schedule with field work 40% complete.

G. Special Reports Issued

1. "PRTR Electrical Design Test Report."
by T. D. Gibbs
2. "Sanitary Water Consumption Forecast, 300 Area."
by R. G. James
3. A paper, "Practical Results of Work Sampling," was presented to the General Electric Company's 11th Regional Plant Engineering and Maintenance Meeting in San Jose, California on November 16, 1960.
by T. H. Whatley
4. "Report of Water Wall Tube Failure, No. 6 Boiler, 384 Building."
by D. L. Traver

III. PERSONNEL

A. Safety, Security and Radiation Experience

Medical Treatment Injuries	22
Frequency Rate	4.30
Disabling Injuries	0
Serious Accidents	0

B. Meetings

Round Table-Staff	18
Safety and Security	16
Information	6

Manager
Plant Facilities Operation

E Hilgeman:GSS:mkm

RELATIONS PRACTICES OPERATION
NOVEMBER, 1960

STATISTICS

<u>EMPLOYMENT</u>	<u>November</u>	<u>October</u>
Additions: Exempt	4	1
Nonexempt	18	8
Total	<u>22</u>	<u>9</u>
Reductions: Exempt	1	2
Nonexempt	6	4
Total	<u>7</u>	<u>6</u>

HEALTH AND SAFETY

Disabling Injuries	0	0
Serious Accidents	1	0
Medical Treatment Injuries	42	39
Medical Treatment Frequency	3.23	2.91

SECURITY

Violations - FPD	1	0
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SUGGESTION PLAN PARTICIPATION

Eligible employees	655	643
FPD suggestions received	67	65
Annualized rate per 1000 eligible employees	1,228	1,213
No. of suggestions adopted	18	29
Net annual saving	\$1,905	\$11,204
Amount of awards	\$ 405	\$ 1,455
Percent of total awards to savings	21.2	13.0
Average amount of awards	\$ 22.50	\$ 50.17

GENERAL

The Department completed its twelfth consecutive month of disabling injury free performance. If this performance is extended through midnight December 20, all Department employees will become eligible for a Safety Council Award. The last award won by employees, a First Presidents Award, was won November 21, 1958.

A study of the safety aspects of beryllium usage in Department manufacturing processes was continued. A meeting of all interested parties who have participated in the investigations to date was held this month to integrate findings. Our pilot plant activities are being audited by Industrial Hygiene and personnel assigned to beryllium work are being given a medical history evaluation by Industrial Medicine.

Preparations for the Department annual report to employees in January proceeded on schedule. A topical outline of subject matter was provided to each Section and preparation of narrative copy was initiated.

Plans were completed for conducting the 1960 appraisal and salary review activity. Tentative schedules were established calling for appraisals to be written and approved by the end of December. The Relations Practices Operation agreed to provide line management with salary action guide lines early in December.

Employment activity increased as anticipated in November. Twenty-two weekly salaried employees were added to the roll compared to nine last month. Additions primarily reflect needs for personnel to support expansion of the manufacturing function.

A recruiting visit was made to the Oregon Technical Institute in Klamath Falls, Oregon. Considerable interest in HAPO was expressed by instrument (electronic) students. Twenty-seven men were interviewed. Offer recommendations were forwarded to the Relations Operation following the visit and three offers were extended by the Department.

Manager - Relations Practices

RW McCullugh:hw

END

**DATE
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11 / 27 / 92